III. METHODOLOGY

PARK-AND-RIDE DEMAND ESTIMATION

Overview

A primary goal of this project was to develop corridor-level demand estimates. A list of primary transit commuting corridors, and in some cases sub-areas, was developed with input from WSDOT and local transit agencies. These transit corridors were broadly defined and can include multiple freeways, state routes, arterials, and transit routes. Permanent park-and-ride lots were grouped into logical corridors reflecting major network, geographic, and service features. Demand for park-and-ride lots was analyzed for these corridors or sub-areas. Analysis at the corridor level allows for more accurate demand forecasting overall, and for more flexibility in the interpretation of the results and in implementation of the proposed programming.

Corridor-level analysis allows the study process to capture both local park-and-ride demand and demand that may be shifting between facilities within the corridor. In some corridors, especially those where demand for park-and-ride has exceeded capacity, lot substitution has been observed. Lot substitution, the phenomenon of patrons passing by the lot closest to their origin in preference for a down-stream facility, can be driven by a number of factors including differences in service, demand to capacity ratios, cost of transit service in different fare zones, facility amenities, and other factors.

In order to quantify corridor-level park-and-ride demand, estimates and forecasts were developed for the years 2000 (existing), 2010, and 2020. A three-part estimation methodology was utilized to calculate demand for these three time periods. The three-part process involved:

- Estimation of existing "unconstrained" park-and-ride facility demand using a regression-based PRD Model developed for the Puget Sound region.

- Forecasting future demand based on existing "unconstrained" estimates, future service assumptions, and **population** growth rates taken from the PSRC EMME2 travel forecasting model.

- Forecasting future demand based on existing "unconstrained" estimates, future service assumptions, and **transit** ridership growth rates taken from the Sound Transit EMME2 travel forecasting model, or from the PSRC model where appropriate.

The two separate estimates developed by the population-based and transit-based growth rates were used to provide a range of possible future forecasts.

The term "unconstrained" is used in this study to denote ideal conditions for capture of park-and-ride market demand. In some cases, the unconstrained year 2000 demand is estimated as higher than existing facility demand. This is because existing utilization may be constrained by factors other than lot size (e.g., facility location and accessibility, type of transit service provided, or a perceived safety concern or lack of other patron amenities). The analysis undertaken in this study was designed to estimate and forecast potential demand, unconstrained by less-than-ideal facility attributes and service characteristics.

The region's park-and-ride system also serves as a staging platform for the vanpool programs of six local transit agencies. In the year 2000, some 1,250 formally organized carpools were

Rose Keir, 20-year vanpool participant

registered by the agencies. Organized car- and vanpools are entitled to priority loading on some of the most popular and congested ferry routes. Similarly, all car- and vanpools, formal or informal, are entitled to use existing park-and-ride facilities. While not all use park-and-ride facilities as a meeting or staging location, regional data suggest that up to 20 percent of vehicles parked at any individual facility may be a car- or vanpool. Demand estimates for existing and future park-and-ride facilities are inclusive of car- and vanpool utilization of the facility.

After generation of future forecasts, facility demand was then aggregated to corridor-level estimates and forecasts. This demand was adjusted based on input from the local transit agencies. The estimates and forecasts were then divided into specific programming recommendations, which were reviewed and adjusted by individual transit agencies based on their knowledge of the study area. All programming suggestions are considered moveable within the transit corridor. The process for estimating existing and future demand is illustrated in Figure 3.1 and 3.2. A more detailed methodology is discussed in the following subsections.

As indicated above, the focus of the demand estimation and forecasting approach was to develop corridor-level demand estimates. Location-specific forecasts developed as part of the process should not be viewed as implementation plans. These forecasts are based on optimistic assumptions about service levels and transit facilities. At the corridor level, such demand estimates are appropriate for planning and programming purposes. For implementation, detailed analyses based on factors such as committed transit services, known service area characteristics, and competing facility locations will need to be considered for site selection and design criteria.

Existing Demand

Existing park-and-ride facility observed demand within the central Puget Sound region often exceeds current facility capacity. Excess demand in the form of illegally parked vehicles at individual facilities, vehicles parked along adjacent streets, and vehicles parked in adjacent properties can be readily identified through field observations (e.g., South Bellevue P&R in King County, Tacoma Dome P&R in Pierce County, Lynnwood Transit Center in Snohomish County, and Harper Evangelical Church in Kitsap County). When demand for individual facilities exceeds available capacity, an unobservable latent demand can develop. Demand observations at individual park-and-ride facilities may therefore substantially under-represent existing demand because of the capacity constraint generated by the full facility.

Similarly, existing park-and-ride investments within individual corridors may not optimally "cover" the demand within the corridor. For example, a theoretically ideal coverage area can be

Figure 3.1

Corridor Demand Estimation Process - Existing Demand

| Define fully covered corridor | → | Estimate "unconstrained" facility demand using regression equation model & optimized existing transit levels for existing facilities and for "missing" facilities. | → | **Sum facility estimates to corridor level** |

Figure 3.2

Corridor Demand Estimation Process – Future Year Demand

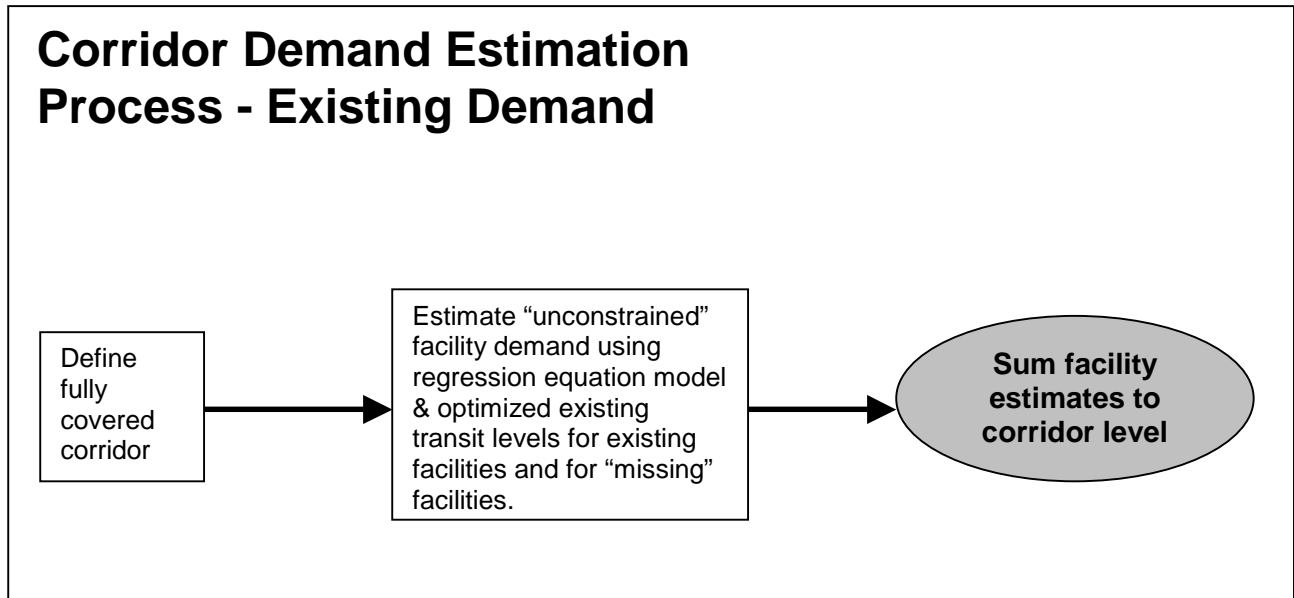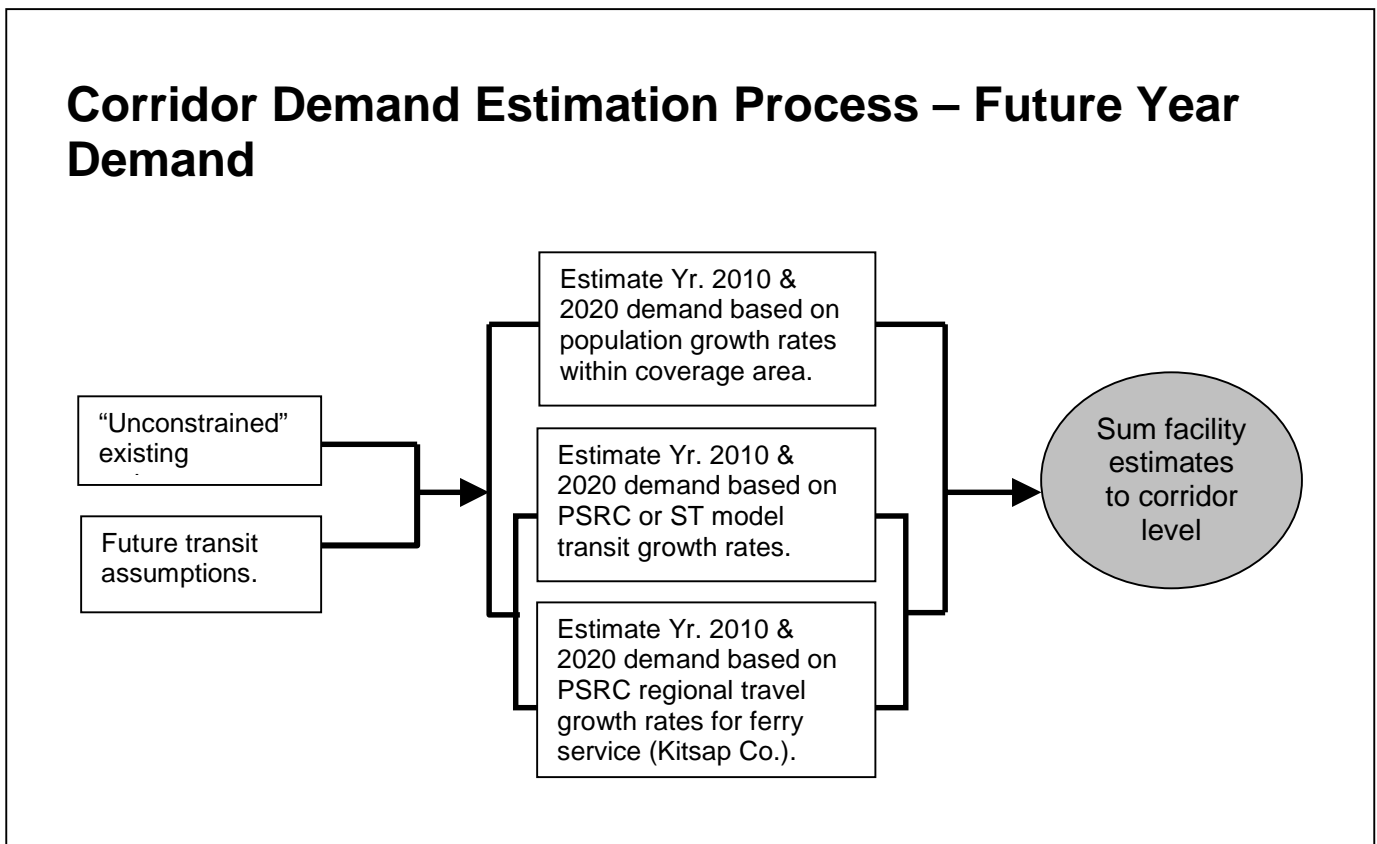| "Unconstrained" existing | | Estimate Yr. 2010 & 2020 demand based on population growth rates within coverage area. | | |
| Future transit assumptions. | → | Estimate Yr. 2010 & 2020 demand based on PSRC or ST model transit growth rates. | → | Sum facility estimates to corridor level |
| | | Estimate Yr. 2010 & 2020 demand based on PSRC regional travel growth rates for ferry service (Kitsap Co.). | | |

identified for each existing park-and-ride facility based on regional statistics.[1] Corridor segments with sufficient adjacent population that do not fall within an ideal coverage area of a park-and-ride facility are underserved. Demand within underserved areas may not be fully realized at existing park-and-ride facilities, thus resulting in latent unmet demand within the system.

To overcome these two limitations, a process to estimate existing demand based on facility characteristics and full corridor coverage was utilized. The process is based on the assumption that to obtain unconstrained corridor estimates, the corridor must be spatially served by sufficient facilities to approximate a fully covered corridor. Furthermore, it is assumed that an unconstrained estimate of park-and-ride demand at individual facilities can be approximated using a regression-based approach.[2]

THE PRD MODEL

The PRD model was used to estimate existing unconstrained facility demand. This model is a spreadsheet model based on a series of regression formulae developed for King County in 1995. The model was based on an analysis of the demand characteristics of thirty-one active lots in the King County system. Input variables include service area population, auto and transit costs, distances to major employment centers, the number of express buses during the AM peak period, best time to central business districts, proximity to the freeway system, number of adjacent park-and-ride facilities, and the availability of midday service. Details regarding the development and use of this model were published in *Park-and-Ride Planning and Design Guidelines*, Parsons Brinckerhoff Monograph #11, October 1997.[3]

The PRD model generates a range of demand estimates for individual facilities based on six regression formulae. Each formula emphasizes one or several of the inputs described above. Depending upon the location of the lot, service characteristics, or other considerations, either an average of all six equations, or the results of subsets of the equations, was chosen for each lot. For example, demand for lots in outlaying areas with low population and very low density land use is more accurately predicted by the formula emphasizing population. Hence, for such lots, only the most population-sensitive equation was used as the predictor of demand. The model parameters and underlying equations are presented in Figure 3.3.

The PRD model is not constrained by the existing capacity provided at current facilities, and therefore can predict latent demand. Facilities used in the derivation of the model ranged in size from approximately 150 spaces to 1000 spaces. Hence, the model is most accurate when used to estimate facilities within this range. However, it is sufficiently flexible and accurate when planning at the regional level to extend this range of applicability down to facilities as small as 100 spaces and for facilities up to 1500 spaces without introducing unreasonable results. As an example of its validation, the PRD model was used to verify the appropriate design characteristics for the newly opened Ash Way Park-and-ride facility in Snohomish County. Demand counts within the first few months of operation and after a normal demand stabilization period were within 30 vehicles of the demand estimates generated by the model.

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[1] Spillar, Robert J., *Park-and-Ride Planning and Design Guidelines,* 1995 William Barclay Parsons Fellowship Monograph #11, Parsons Brinckerhoff, New York NY, 1997.

[2] Ibid.

[3] Ibid.

Figure 3.3

DEFINITION OF MODEL VARIABLES

ATRANCOST   Ratio of Auto Operational Cost to Transit Cost. Auto Operational Costs includes parking costs.
AMBUS   Number of Express Bus Trips to Seattle CBD from the Park and Ride lot during the AM Peak period
AMBUSROOT   Square root of **AMBUS**
CBDSQ   Square of the distance in miles from the subject Park and Ride lot to Seattle CBD
FREEWAY   Boolean variable to capture proximity to Freeway. This variable takes the value 1 or 0
TRANSPD   Speed of Transit in mph expressed as a ratio of distance from the subject Park and Ride lot to the Seattle CBD to the best scheduled time to reach CBD from the Park and Ride lot
LOG_SPD   Natural logarithm (ln) of **TRANSPD**
ADJSPACE   Number of spaces in the adjacent park and ride lots within a 2.5 mile radius from the subject park and ride lot
UWTIME   Transit travel time from the subject park and ride lot to University of Washington District
MIDDAY   Boolean variable to capture presence of midday transit service from and to the subject park and ride lot
NUMLOTS   Number of adjacent park and ride lots within a 2.5 mile radius from the subject park and ride lot

MODEL 1 ADJ R^2 = 0.447   N=31   STD. DEV = 128

DEMAND = -45.664 + 52.687 * AMBUSROOT + 0.600 * CBDSQ + 129.904 * FREEWAY

MODEL 2 ADJ R^2 = 0.645   N=22   STD. DEV = 84

DEMAND = -1109.418 + 71.205 * AMBUSROOT + 126.2 * FREEWAY + 332.516 * LOG_SPD
              + 0.054 * ADJSPACE

MODEL 3 ADJ R^2 = 0.415   N=31   STD. DEV = 131

DEMAND = -815.390 + 42.069 * AMBUSROOT + 125.451 * FREEWAY + 291.503 * LOG_SPD

MODEL 4 ADJ R^2 = 0.403   N=31   STD. DEV = 133

DEMAND = -128.492 + 118.469 * ATRANCOST + 37.965 * AMBUSROOT + 152.677 * FREEWAY

MODEL 5 ADJ R^2 = 0.620   N=22   STD. DEV = 84

DEMAND = -359.661 + 73.236 * AMBUSROOT + 145.392 * FREEWAY + 13.219 * TRANSPD

MODEL 6 ADJ R^2 = 0.694   N=22   STD. DEV = 92

DEMAND = (-21.459 + 20.558 * FREEWAY + 35.169 * MIDDAY + 12.590 * NUMLOTS
              + 0.673 * UWTIME) * TOTPOP / 10,000

Note: Major local destinations can be substituted for the Seattle CBD. See individual county methodologies.
Source: Parsons Brinckerhoff

Coverage Areas

An initial step in the corridor estimation process involves the definition of ideal coverage areas for individual park-and-ride facilities within each corridor. Major park-and-ride facilities within each transit corridor were identified, and a typical service area then applied to each lot. Based on research in the Puget Sound region described in *Park-and-Ride Planning and Design Guidelines*, a circular 2.5-mile radius area centered on each park-and-ride facility was used as the assumed ideal coverage service area. Holes or underserved areas were then identified from the spatial distributions observed for existing park-and-ride facilities. Where underserved areas were identified, hypothetical placeholder or "proxy" facilities were located. On the other hand, where several permanent facilities were located closely together, or an adjacent facility was determined to be "minor," one or more existing park-and-ride lots may have been combined together. This allowed for an analysis of existing demand unconstrained by less-than-ideal facilities or facility placements.

Identified coverage areas for park-and-ride facilities within each county's transit corridors are shown by county in the following chapters. Proxy lots and combined existing lots were located for analysis purposes, and do not suggest finalized recommendations. Identified coverage areas should also not be mistaken for full draw areas. Based on research in the *Guidelines,* approximately 50 percent of a typical park-and-ride lot will normally draw from within the circular 2.5 mile radius area. The PRD model equations are developed to estimate full (100 percent) facility demand based on this reduced service area definition (i.e., 2.5 mile radial area).

Transit Assumptions

The PRD model also requires the input of transit assumptions. In order to estimate "unconstrained" park-and-ride demand, reasonably aggressive existing and future transit service levels were assumed. These assumptions were developed in close concert with individual transit agencies and are identified by county in the following chapters.

Future Demand

An unconstrained year 2000 demand was estimated based on the PRD methodology, and used as the base level for existing demand. This demand was then grown at both the rate of population growth as extracted from the PSRC EMME2-based model, and the rate of ridership growth as extracted from the Sound Transit EMME2-based travel model, Locally Preferred Alternative (LPA).

The Sound Transit model is an incremental model that pivots off of existing demand and service levels. This is in contrast to the PSRC model that is a fully synthetic model inclusive of the full four-step modeling process, based on Vision 2020 land use assumptions. Kitsap County and other outlying areas of the region are outside Sound Transit's LPA forecast area. For these areas, the PSRC model output was used to determine ridership growth rates.

The two separate scenarios represented by the population-based and transit-based growth rates were used in order to provide a range of possible future forecasts. These two approaches are discussed in more detail below.

POPULATION-BASED GROWTH FACTORS

The population-based projection method assumes as an underlying basis that park-and-ride demand can be directly linked to population in the coverage areas of each transit corridor.

Although there are certainly more factors that affect park-and-ride demand (freeway congestion, transit service levels, parking costs at employment centers, etc.), population growth can be a key indicator for anticipated growth in usage. Growth rates were calculated by corridor and applied to estimated existing demand at each facility, both existing and proxy, that comprise a corridor. Population-based forecasts generally provided the low end of the forecasting range for future demand because they imply that existing demand as a percent of the commuting market is stable and that future demand can be predicted by a straight-line forecast approach based solely on population growth. Using this method, no allowances are made for future modal shift resulting from system-wide transit improvements and/or increasing arterial and freeway congestion.

TRANSIT-BASED GROWTH FACTORS

The transit-based projection method assumes that park-and-ride demand grows at a similar rate to the forecasted background growth in transit demand in the coverage area of each transit corridor. Growth rates were calculated by corridor and applied to estimated existing demand at each facility, both existing and proxy, that comprise a corridor. The transit-based forecasts were generally higher than the population-based forecasts because transit modal share is generally expected to increase as transit improvements are realized, urban and suburban areas of the region continue to densify, and non-transit travel networks become increasingly congested.

Corridor-Specific Adjustments

A uniform methodology was applied throughout the study area in order to assure consistency of findings. The three-pronged approach outlined above allowed for minor modifications to be made for each county to reflect unique characteristics within corridors. Because the PRD model was primarily developed in King County, adjustments were required to validate the model for use in Kitsap, Pierce, and Snohomish Counties. These adjustments were made on a primarily trial-and-error basis in order to obtain reasonable existing condition estimates. Once validated for the existing conditions, these modifications were maintained into the forecasting of future demand levels.

For example, in Kitsap County the travel time between the subject park-and-ride facility and the nearest ferry terminal offering service to Seattle was found to be a better indicator variable than the full travel time to the Seattle CBD. This variable substitution was therefore made for all Kitsap County estimates. In all cases, forecasts resulting from variable substitution were reviewed and approved by local transit agencies.

Details of corridor-specific methodological adjustments are presented by county in the following chapters.

PROGRAMMING

This study provides an estimate of demand through 2020 and a list of potential capital projects phased through the PSRC 2030 planning horizon. These projects represent a financially unconstrained view and are not prioritized beyond their phasing. Capital projects were programmed over three planning periods: short-range (2000-2006), mid-range (2007-2015), and long-range (2016-2030). Short-range projects consist of those projects already programmed by participating agencies. Assuming that the programming of facilities typically

lags behind demand, the project list for future time periods responds to the previous period's demand estimate, as follows:

Period	Demand Year	Program Period
Short-Term	2000 pipeline projects	2000-2006
Mid-Range	2000 unmet demand	2007-2015
Long-Range	2010	2016-2020
Long-Range	2020	2030 MTP horizon

Project recommendations were reviewed with WSDOT and the participating transit agencies to assure consistency with current agency planning efforts, and for completeness and reasonableness. Projects were added, deleted, and moved forward or backward in time to better meet an agency's objectives. Project location, size, and type of facility were also determined through this iterative process. It must be emphasized that this program is not financially constrained and that fulfillment of total park-and-ride demand may be neither feasible nor desirable. This issue must be addressed at the corridor policy level and at facility implementation.

During the identification of corridor projects for each county, two important assumptions were utilized:

- A 20 percent reserve capacity was added to parking demand in order to account for growth in carpool and vanpool operations, for midday usage of the facility, and for short-term use of spaces. It should be noted that carpool and vanpool lot use is already included in the model estimation, so this reserve capacity would be for growth in current rates only. It is also assumed that agencies will begin to define park-and-ride facilities as being "full" once they near the 80 percent utilization level. (Note: carpool, vanpool, and rideshare demand, as well as the criterion that trigger facility expansion are influenced by policy. Future updates to the park-and-ride system plan and individual site design efforts should explicitly review current policy on these issues to assure consistency with current standards and needs.).

- In instances where existing capacity exceeds demand, it was assumed that 50% of excess capacity may eventually be put into use through improved bus service, improved user information, and expanded marketing, or other means of attracting users.

An eight-step process was used to identify corridor programming needs based on the projected demand estimates. These identified programming needs take into account existing and future capacity shortfalls, transit agency policies, and system-wide demand. This eight-step process is described in detail below, and represented in Figure 3.4.

STEP ONE: Existing capacity is discounted by 20 percent to allow for operational reserve.

Adjusted Existing Capacity = Existing Capacity minus 20%

STEP TWO:

Available Capacity = Adjusted Existing Capacity minus Observed 2000 Usage

STEP THREE: In some instances, existing capacity may be underused. For the purposes of this study, it is assumed that 50 percent of unused capacity will count towards existing estimated demand, therefore:

If Available Capacity > 0 (unused capacity) then Adjusted Available Capacity = ½ Available Capacity

STEP FOUR :

Unmet 2000 Demand = 2000 Estimated Demand minus Observed 2000 Usage

STEP FIVE:

2000 Need = (Unmet 2000 Demand minus Adjusted Available Capacity) plus 20% Reserve

Short-Term Projects

Short-range projects consist of those projects already programmed by participating agencies (Six-Year Programs)

STEP SIX:

Mid-Range 2007-2015 Need

Unmet 2000 Need = 2000 Need minus Six-Year Program

STEP SEVEN:

Long-Range 2016-2020 Need

2010 Need = [(2010 Demand minus 2000 Estimated Demand) minus 2000 Unused Capacity] plus 20% Reserve
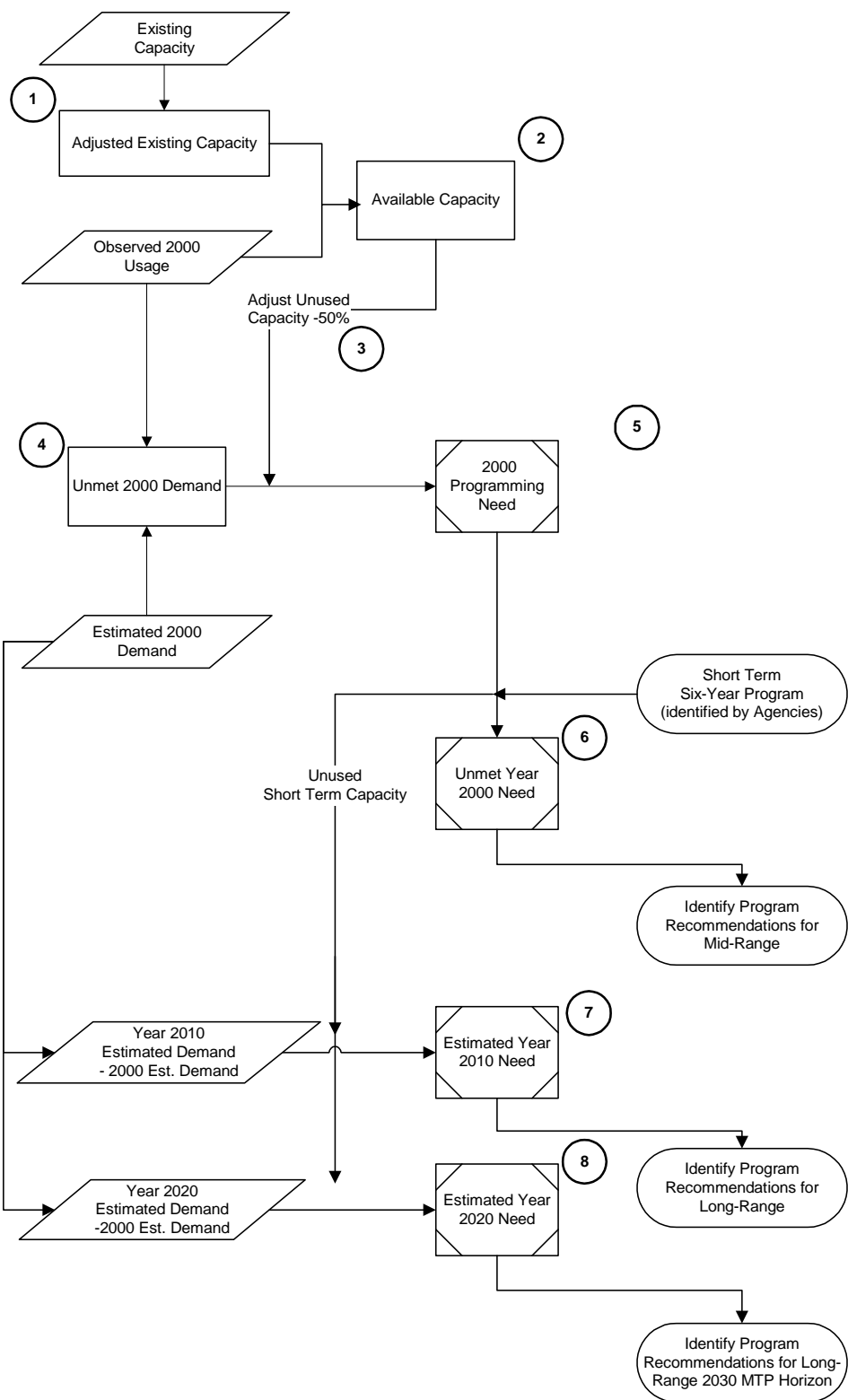
2000 Unused Capacity = 2000 Need < 0

STEP EIGHT:

Long-Range MTP Horizon Need

2020 Need = [(2020 Demand minus 2010 Demand) minus 2010 Unused Capacity] plus 20% Reserve

Figure 3.4

Eight-Step Programming Process

```
                    ┌──────────────────┐
                   /  Existing          /
                  /   Capacity         /
                 └──────────────────┘
                          │
    (1)          ┌────────▼─────────┐
                 │ Adjusted Existing │────────┐
                 │     Capacity      │        │         (2)
                 └──────────────────┘        │    ┌──────────────┐
                                             └───▶│  Available    │
                   ┌──────────────────┐          │  Capacity     │
                  /  Observed 2000     /─────────┘└──────────────┘
                 /   Usage            /                  │
                └──────────────────┘      Adjust Unused  │
                          │               Capacity -50%  │
                          │                    (3)       │
                          │                              │
    (4)                   │            (5)               │
                 ┌────────▼─────────┐      ┌─────────────▼──┐
                 │ Unmet 2000 Demand │────▶│   2000          │
                 └──────────────────┘      │   Programming   │
                          ▲                │   Need          │
                          │                └─────────────────┘
                   ┌──────────────────┐            │
                  /  Estimated 2000    /            │
                 /   Demand           /             │
                └──────────────────┘               │
                          │                         │
                          │         ┌───────────────▼────────┐
                          │         │  Short Term            │
                          │         │  Six-Year Program      │
                          │         │  (identified by        │
                          │         │   Agencies)            │
                          │               (6)       │
                          │      Unused      ┌───────▼───────┐
                          │   Short Term     │ Unmet Year    │
                          │    Capacity      │ 2000 Need     │
                          │                  └───────────────┘
                          │                          │
                          │                  ┌───────▼──────────┐
                          │                  │ Identify Program  │
                          │                  │ Recommendations   │
                          │                  │ for Mid-Range     │
                          │                  └──────────────────┘
                          │                     (7)
           ┌──────────────────┐         ┌──────────────┐
          /  Year 2010         /────────▶│ Estimated Year│
         /   Estimated Demand /          │ 2010 Need     │
        /    - 2000 Est. Demand          └──────────────┘
        └──────────────────┘                     │
                          │               ┌───────▼──────────┐
                          │               │ Identify Program  │
                          │               │ Recommendations   │
                          │               │ for Long-Range    │
                          │  (8)          └──────────────────┘
           ┌──────────────────┐         ┌──────────────┐
          /  Year 2020         /────────▶│ Estimated Year│
         /   Estimated Demand /          │ 2020 Need     │
        /    -2000 Est. Demand           └──────────────┘
        └──────────────────┘                     │
                                          ┌───────▼──────────────┐
                                          │ Identify Program      │
                                          │ Recommendations for   │
                                          │ Long-Range 2030 MTP   │
                                          │ Horizon               │
                                          └──────────────────────┘
```

COST ESTIMATING

In order to help develop programming level cost estimates for facilities, unit costs were derived for each county. These costs were based on current and completed projects and then adjusted as needed to reflect each agency's individual implementation experiences. While these cost assumptions tend to be conservative, they are given as order of magnitude estimates. More detailed costs estimates will need to be developed at the time of implementation. All cost estimates are stated in constant 2000 dollars.

Unit costs for construction were developed for both surface parking and parking structures by county. For surface parking, stalls were assumed at a size of 800 square feet to allow for landscaping and circulation. Structured parking was assumed to require 400 square feet per stall for right-of-way (footprint) calculations. Because of the tremendous range in land values witnessed in the region, right of way cost assumptions were developed for each county and sub area to more accurately reflect variations. Each county used a slightly different approach for determining land value. Kitsap, for example, used "high cost" and "average cost" assumptions as appropriate for individual project locations, whereas King County used the generalized geographic areas of "North", "South", and "East".

Table 3.1 summarizes the cost assumptions used for programming cost estimates. Detailed cost information is presented by County in the following sections.

Table 3.1

Cost Assumptions by County					
County	Type of Facility	Construction Cost/Stall	ROW Cost Per Stall by Area		
			North	South	East
King	Structure	$15,000	$17,500	$6,500	$12,800
	Surface	$10,000	$35,000	$13,000	$25,600
			High Cost	Average Cost	
Kitsap	Structure	$20,000	$12,000	$1,250	
	Surface	$5,000	$24,000	$2,500	
			SW Urban	N & E Urban	Rural
Snohomish	Structure	$15,000	$8,000	$6,000	$3,500
	Surface	$5,000	$16,000	$12,000	$7,000
			Urban	Rural	
Pierce	Structure	$20,000	$10,750	$3,500	
	Surface	$10,000	$21,500	$7,000	

Source: Parsons Brinckerhoff